NEOSHO RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Water Body: Marion Lake (Marion Reservoir)
Water Quality Impairment: Eutrophication

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Upper Cottonwood **Counties:** Marion and McPherson

HUC 11 (HUC 14)**:** **11070202 010** (010, 020, 030, 040, 050) (Figure 1)

Ecoregion: Central Great Plains/Smoky Hills (27a)
Central Great Plains/Wellington-McPherson Lowland (27d)
Flint Hills (28)

Drainage Area: Approximately 204 square miles.

Conservation Pool: Area = 5,376 acres
Watershed Area: Lake Surface Area = 24:1
Maximum Depth = 8.5 meters (28 feet)
Mean Depth = 3.4 meters (11 feet)
Retention Time = 2.2 years (26 months)

Designated Uses: Primary and Secondary Contact Recreation; Expected Aquatic Life Support; Drinking Water; Industrial Water Supply Use; Food Procurement

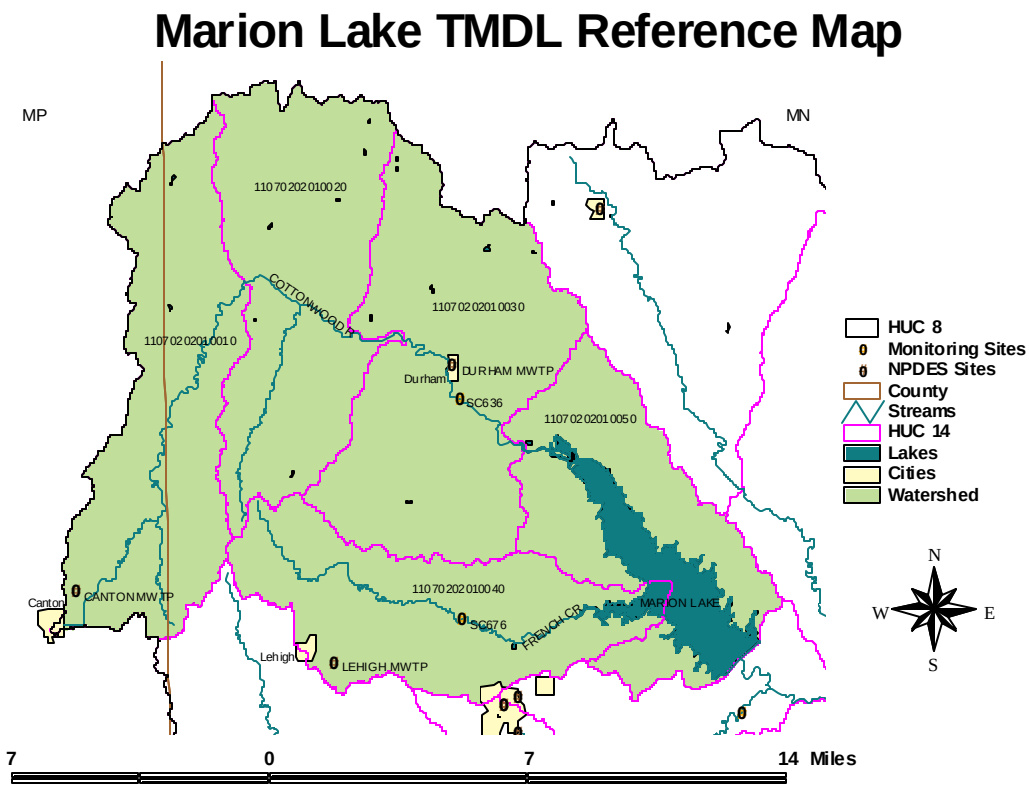
Authority: Federal (U.S. Army Corps of Engineers), State (Kansas Water Office)

2002 303(d) Listing: Neosho Lakes

Impaired Use: All uses are impaired to a degree by eutrophication

Water Quality Standard: Nutrients - Narrative: The introduction of plant nutrients into streams, lakes, or wetlands from artificial sources shall be controlled to prevent the accelerated succession or replacement of aquatic biota or the production of undesirable quantities or kinds of aquatic life. (KAR 28-16-28e(c)(2)(B)).
The introduction of plant nutrients into surface waters designated for primary or secondary contact recreational use shall be controlled to prevent the development of objectionable concentrations of algae or algal by-products or nuisance growths of submersed, floating, or emergent aquatic vegetation. (KAR 28-16-28e(c)(7)(A)).

Figure 1



2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Eutrophication: Fully Eutrophic, Trophic State Index = 56.69

Lake Monitoring Site: Station 020001 in Marion Lake; Six surveys during 1987 - 2002.

Stream Chemistry Sites: Station 636 North Cottonwood River near Durham; 1993 - 2001
Station 676 French Creek near Hillsboro; 1993 - 2001

Current Condition: Marion Lake has chlorophyll a concentrations averaging 14.3 ppb (Appendix A). This relates to a Trophic State Index of 56.69. Sampling done by KDHE shows elevated total phosphorus concentrations (averaging 81.3 ppb). The Total Kjeldahl Nitrogen concentrations average 0.97 mg/L; nitrate concentrations average 0.29 mg/L; and nitrite concentrations average 0.08 mg/L. Light is indicated to be the primary limiting factor (Appendix B). The chlorophyll a to total phosphorus yield is moderately low. Overall, the algal production is slightly reduced because light cannot penetrate through the turbid water. Wind mixing may stir up enough nutrients from the bottom sediment to allow the algal community to proliferate.

Average Sample Concentrations from Marion Lake

Date	Secchi Disc Depth (m)	Chlorophyll a (ug/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)	Turbidity (Formazin Turbidity Units)	Elevation (ft)
9/9/1987		6.35	0.01	18		
6/4/1990	0.90	19.85	0.08		16	
6/15/1993	0.80	1.65	0.10	12	8	
6/4/1996	0.60	14.70	0.06	14	8	1351.59
6/21/1999	0.53	5.35	0.10	21	16	1350.74
8/5/2002	0.64	38.15	0.14	18	10	1349.34

* Conservation Pool = 1,350.5 ft

The Trophic State Index is derived from the chlorophyll a concentration. Trophic state assessments of potential algal productivity were made based on chlorophyll a concentrations, nutrient levels and values of the Carlson Trophic State Index (TSI). Generally, some degree of eutrophic conditions is seen with chlorophyll a concentrations over 7 Fg/l and hypereutrophy occurs at levels over 30 Fg/l. The Carlson TSI, derives from the chlorophyll concentrations and scales the trophic state as follows:

1. Oligotrophic TSI < 40
2. Mesotrophic TSI: 40 - 49.99
3. Slightly Eutrophic TSI: 50 - 54.99
4. Fully Eutrophic TSI: 55 - 59.99
5. Very Eutrophic TSI: 60 - 63.99
6. Hypereutrophic TSI: $ 64

Loads were calculated for the French Creek and North Cottonwood River subwatersheds. From this analysis, it is evident that the North Cottonwood subwatershed is making the greatest contribution to the phosphorus load. The total phosphorus concentrations from station 636 on the North Cottonwood River and from station 676 on French Creek are not statistically different. Therefore, the different in the median flows account for the difference in load.

The greatest amounts of Total Phosphorus are seen at the stream stations during winter (Appendix C). Mau and Pope have determined that fertilizer applications, confined animal feeding operations, animals grazing on pasture land, and NPDES facilities are the sources of nutrients under low flow conditions.

Average Concentrations and Load at Stream Monitoring Stations

KDHE Station (USGS Station)	Total Phosphorus (mg/L)	Median Flow (cfs)	Flow Weighted Total Phosphorus Load (lb/day)
North Cottonwood River Station 636 (Matched to flow duration for Cedar Creek near Cedar Point (07180500))	0.229	12.5	15.5
French Creek Station 676 (Matched to flow duration for Cedar Creek near Cedar Point (07180500))	0.241	2.6	3.4

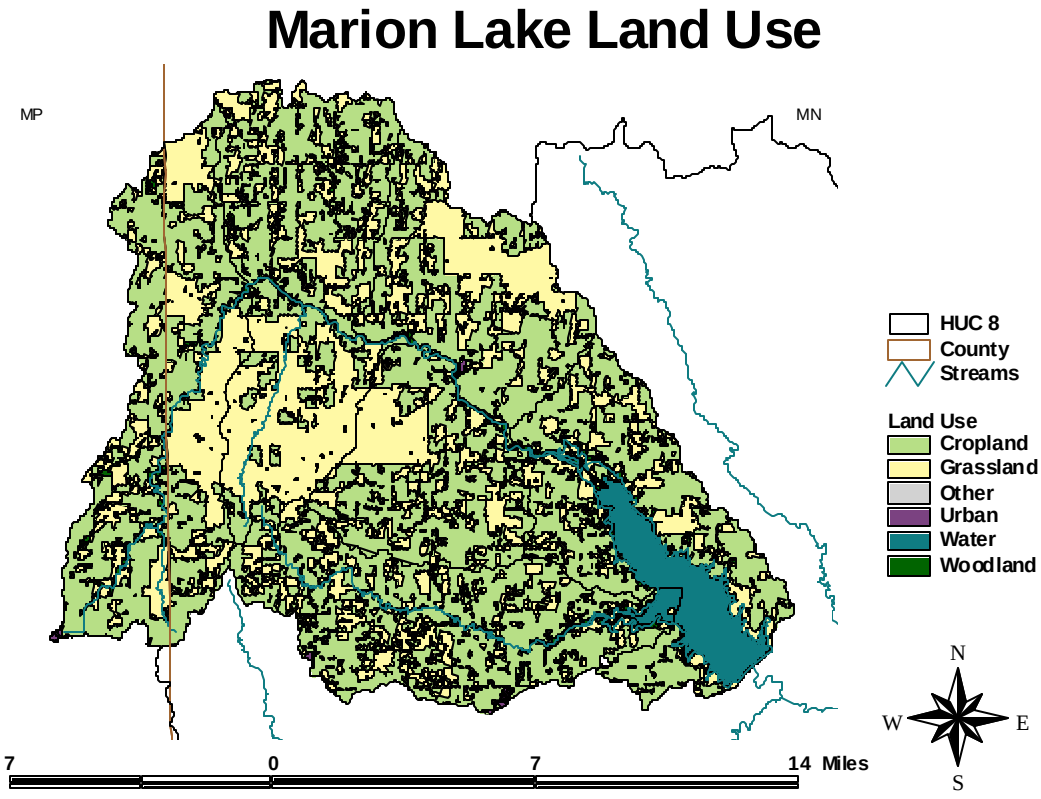
Interim Endpoints of Water Quality (Implied Load Capacity) at Marion Lake over 2007 - 2011:

Current Condition and Reductions for Marion Lake

Parameter	Current Condition	TMDL	Percent Reduction
Total Phosphorus Load (lb/year)	**133,299**	**33,527**	**75 %**
Total Phosphorus Concentration (Fg/L)*	**81.3**	**38.8**	**52 %**
Chlorophyll a (Fg/L)	**14.3**	**< 12**	**16 %**

In order to improve the trophic condition of the lake from its current Fully Eutrophic status, the desired endpoint will be to maintain summer chlorophyll a concentrations below 12 Fg/L.

3. SOURCE INVENTORY AND ASSESSMENT
Figure 2



NPDES: Three NPDES permitted facilities are located within the watershed (Figure 1). One is a non-overflowing lagoon. Non-overflowing lagoons are prohibited from discharging and would only contribute a total phosphorus or ammonia load under extreme precipitation events (flow durations exceeded up to 5 percent of the time). Such events would not occur at a frequency or for a duration sufficient to add to the impairments in Marion Lake.

Based on the design flow and the estimated total phosphorus loading from the lagoon and mechanical plant, the current total phosphorus load is 1,782 pounds per year. Below is a list of the NPDES facilities and their wasteload allocation.

NPDES Facilities in the Marion Lake Watershed

Permit Number	Facility Name	Type	Design Flow	TP (mg/L)	TP Load (lbs/day)
M-NE09-OO01	CANTON MWTP	Trickling Filter	0.15	3.5	4.4
M-NE19-NO01	DURHAM MWTP	Four-Cell Lagoon	Non-Overflowing	0.0	0.0
M-NE41-OO01	LEHIGH MWTP	Three-Cell Lagoon	0.03	2	0.5

The point source contribution is derived from monitoring data from the waste treatment plants and other point source pollution contributors. When sufficient, effluent discharge data is not available, the following concentrations are used to calculate the waste load allocations for waste treatment plant lagoons and municipal mechanical plants:

Average Concentration in Municipal Facilities that Meet Baseline Design

Facility Type	**Total Phosphorus**	**Total Nitrogen**
Waste Treatment Plant Lagoon	2.0 mg/L	7.0 mg/L
Mechanical Plant – Trickling Filter	3.5 mg/L	20.0 mg/L
Mechanical Plant – Activated Sludge only fully nitrify	3.5 mg/L	25.0 mg/L
Mechanical Plant – Activated Sludge fully nitrify and de-nitrify	3.5 mg/L	10.0 mg/L

Canton MWTP has been monitoring for total phosphorus for five months. Over that time frame, the average daily load was 3.2 lbs/day of total phosphorus. One sample taken by USGS below Canton in December 1998 had a concentration of 2.5 mg/L of Total Phosphorus.

In December 1998, the USGS also took one sample below the Lehigh MWTP. The Total Phosphorus concentration was 0.30 mg/L. Lehigh MWTP will have a wasteload allocation that represents the baseline design for a similar facility. Therefore, the wasteload allocation is set at 0.5 pounds per day. In both situations phosphorus levels declined in a downstream direction before reaching the lake, indicating nutrients were being tied up by stream biology or stream sediments.

Land Use: The watershed around Marion Lake has a high potential for nonpoint source pollutants. The watershed contribution is 133,299 pounds per year.

One source of phosphorus within the Marion Lake watershed is probably runoff from agricultural lands where phosphorus has been applied. Land use coverage analysis indicates that 58% of the watershed is cropland (Figure 2).

Phosphorus from animal waste is a contributing factor. Animal waste, from livestock waste management systems, may add to the phosphorus load going into the lake. However, given the controls for the systems, animal waste coming from grazing areas is a more likely contributor. Thirty-six percent of land around the lake is grassland; the grazing density of livestock is moderate in summer and high in winter. Animal waste, from confined animal feeding operations, adds to the phosphorus load going into Marion Lake (Figure 3). There are 11 dairy, 20 beef, and 5 swine animal feeding operations in the watershed. All permitted livestock facilities have waste management systems designed to minimize runoff entering their operations or detaining runoff emanating from their areas. Such systems are designed for the 25 year, 24 hour rainfall/runoff event, which would be indicative of flow durations well under 10 percent of the time. In Marion County, where many of the facilities are relatively close to the river, such an event would generate 6.1 inches of rain, yielding 4.9 to 5.7 inches of runoff in a day. NPDES permits, also non-discharging, are issued for facilities with more than 1,000 animal units. The facilities in this watershed are not of this size. Potential animal units for the facilities in the watershed total 8,673. The actual number of animal units on site is variable, but typically less than potential numbers. The estimated number of animals listed above are less than those cited in the USGS report. The USGS report counted animals on open range or in operations with less than 300 animal units. Small livestock operations are not tracked by KDHE.

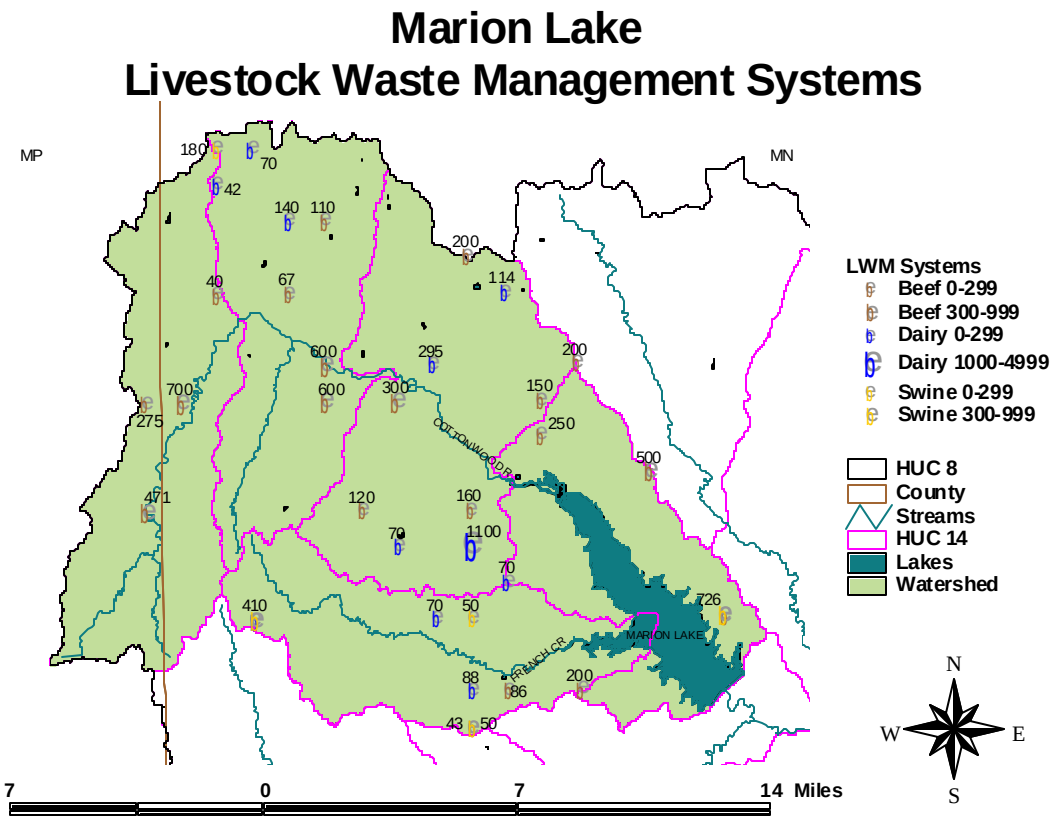
Septic systems are located around the lake. Failing septic systems can be a significant source of nutrients. Marion County has approximately 1,666 septic systems. Less than one percent of the watershed is urban; stormwater runoff and urban fertilizer applications are a minor contributing factor. The population density of the watershed is 9.8 people per square mile. Among the four cities within the watershed, the following population changes are expected:

Expected Population Change from 2000-2020

Name	**% Change**
Canton	16.7%
Durham	-11.4%
Hillsboro	27.2%
Lehigh	5.1%

Background Levels: Two percent of land in the watershed is woodland; leaf litter may be contributing to the nutrient loading. The atmospheric phosphorus and geological formations (i.e., soil and bedrock) may contribute to phosphorus loads. Carp and wind mixing may cause some resuspension of sediment.

Figure 3



4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

While light is the limiting factor in Marion Lake, Total Phosphorus is also allocated under this TMDL. The Load Capacity is 33,527 pounds per year of phosphorus. More detailed assessment of sources and confirmation of the trophic state of the lake must be completed before detailed allocations can be made. The general inventory of sources within the drainage does provide some guidance as to areas of load reduction.

Point Sources: This impairment is associated with the Waste Treatment Plants. Ongoing inspections and monitoring of these NPDES sites will be made to ascertain the contributions that have been made by the source. These Waste Treatment Plants should comply with any future permit limits. The Wasteload Allocation should be at 1,782 pounds of total phosphorus per year. (See page 5 for the

detailed Waste Load Allocations). As previously noted in the inventory and assessment section, the non-discharging permitted municipal facility waste management system located within the watershed does not discharge with sufficient frequency or duration to add to an impairment in the lake. Therefore, the Wasteload Allocation for Durham MWTP is 0 pounds of total phosphorus per year.

Nonpoint Sources: Nonpoint source pollutants contribute to the water quality violations. Background levels may be attributed to atmospheric and geological sources. The assessment suggests that cropland and animal waste contribute to the elevated total phosphorus concentrations in the lake. Generally a Load Allocation of 28,392 pounds of total phosphorus per year, leading to a 75% reduction, is necessary to reach the endpoint.

Defined Margin of Safety: The margin of safety provides some hedge against the uncertainty of variable annual total phosphorus loads and the chlorophyll a endpoint. Therefore, the margin of safety will be 3,353 pounds per year of total phosphorus taken from the load capacity subtracted to compensate for the lack of knowledge about the relationship between the allocated loadings and the resulting water quality.

State Water Plan Implementation Priority: Because Marion Lake is a federal reservoir with a relatively large watershed and a large regional benefit for recreation and state invested water supply, this TMDL will be a High Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Upper Cottonwood (HUC 8: 11070202) with a priority ranking of 36 (Medium Priority for restoration).

Priority HUC 11s: The entire watershed is within HUC 11070202010.

5. IMPLEMENTATION

Desired Implementation Activities

There is a very good potential that agricultural best management practices will allow improved use support to take place in Marion Lake. Some of the recommended agricultural practices are as follows:

1. Implement soil sampling to recommend appropriate fertilizer applications on cropland.
2. Maintain conservation tillage and contour farming to minimize cropland erosion.
3. Install grass buffer strips along streams.
4. Reduce activities within riparian areas.
5. Implement nutrient management plans to manage manure application to land.

Implementation Programs Guidance

NPDES-KDHE

a. Evaluate nutrient loading from municipal dischargers in the watershed.

b. Work with those dischargers on reducing their individual loadings.

Nonpoint Source Pollution Technical Assistance - KDHE

a. Support Section 319 demonstration projects for reduction of sediment runoff from agricultural activities as well as nutrient management.

b. Provide technical assistance on practices geared to establishment of vegetative buffer strips.

c. Provide technical assistance on nutrient management in vicinity of streams.

d. Develop a Watershed Restoration and Protection Strategy for HUC 11070202.

Water Resource Cost Share Nonpoint Source Pollution Control Program - SCC

a. Apply conservation farming practices, including terraces and waterways, sediment control basins, and constructed wetlands.

b. Provide sediment control practices to minimize erosion and sediment and nutrient transport.

Riparian Protection Program - SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.

b. Develop riparian restoration projects.

c. Promote wetland construction to assimilate nutrient loadings.

Buffer Initiative Program - SCC

a. Install grass buffer strips near streams.

b. Leverage Conservation Reserve Enhancement Program to hold riparian land out of production.

Extension Outreach and Technical Assistance - Kansas State University

a. Educate agricultural producers on sediment, nutrient, and pasture management.

b. Educate livestock producers on livestock waste management and manure applications and nutrient management planning.

c. Provide technical assistance on livestock waste management systems and nutrient management plans.

d. Provide technical assistance on buffer strip design and minimizing cropland runoff.

e. Encourage annual soil testing to determine capacity of field to hold nutrients.

Time Frame for Implementation: Pollutant reduction practices should be installed within the priority subwatersheds before 2007, with minor followup implementation, including other subwatersheds over 2007-2011.

Targeted Participants: Primary participants for implementation will be agricultural producers within the drainage of the lake. Initial work in before 2007 should include local assessments by conservation district personnel and county extension agents to locate within the lake drainage:

1. Total row crop acreage

2. Cultivation alongside lake
3. Drainage alongside or through animal feeding lots
4. Livestock use of riparian areas
5. Fields with manure applications

Milestone for 2007: The year 2007 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, sampled data from Marion Lake should indicate evidence of reduced phosphorus levels in the conservation pool elevations relative to the conditions seen over 1987-2002.

Delivery Agents: The primary delivery agents for program participation will be conservation districts for programs of the State Conservation Commission and the Natural Resources Conservation Service. Producer outreach and awareness will be delivered by Kansas State Extension.

Reasonable Assurances:

Authorities: The following authorities may be used to direct activities in the watershed to reduce pollutants.

1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

3. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.

4. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan.*

6. The *Kansas Water Plan* and the Neosho Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a High Priority consideration.

Effectiveness: Nutrient control has been proven effective through conservation tillage, contour farming and use of grass waterways and buffer strips. The key to success will be widespread utilization of conservation farming within the watersheds cited in this TMDL.

6. MONITORING

Additional data, to establish nutrient ratios, source loading and further determine mean summer lake trophic condition, would be of value prior to 2007. Further sampling and evaluation should occur once before 2007 and twice between 2007 and 2011. Some monitoring of tributary levels of nutrients will help direct abatement efforts toward major contributors. Additionally, tracking of nutrient loads from the existing municipal lagoons should be done to confirm the low contribution to the lake.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Neosho Basin were held January 9, 2002 in Burlington and March 4, 2002 in Council Grove. An active Internet Web site was established at http://www.kdhe.state.ks.us/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Neosho Basin.

Public Hearing: Public Hearings on the TMDLs of the Neosho Basin were held in Burlington and Parsons on June 3, 2002.

Discussion with Interest Groups: Meetings to discuss TMDLs with interest groups include:
Marion Reservoir 319 Water Quality Project Buffer Initiative: June 16, 2004

Basin Advisory Committee: The Neosho Basin Advisory Committee met to discuss the TMDLs in the basin on October 2, 2001, January 9, March 4, and June 3, 2002.

Milestone Evaluation: In 2007, evaluation will be made as to the degree of implementation which has occurred within the watershed and current condition of Marion Lake. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

Consideration for 303(d) Delisting: The lake will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2007-2011. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the ten-year implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

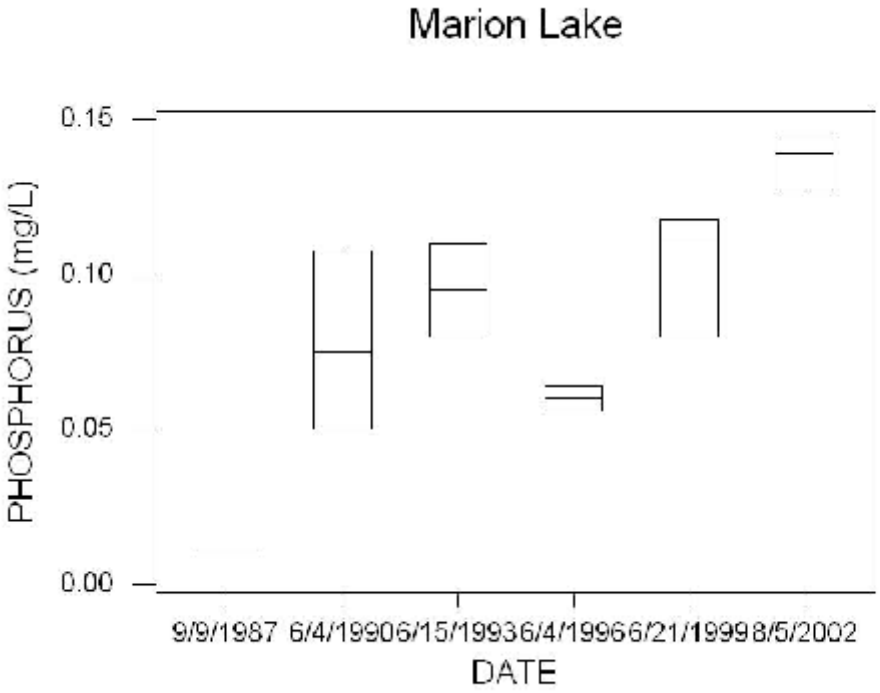
Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision will come in 2003 which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2003-2007.

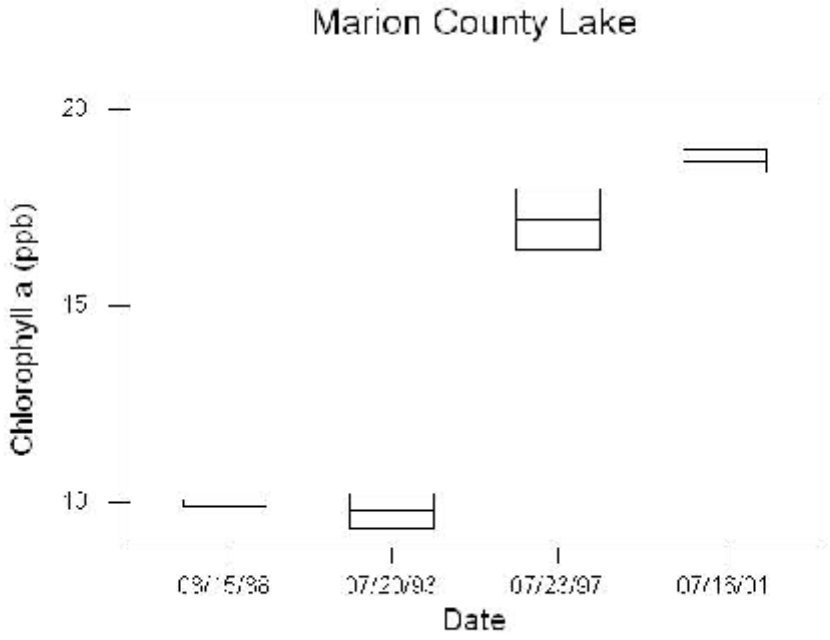
Bibliography

Liscek, Bonnie C. Methodology Used in Kansas Lake TMDLs [web page] Jul. 2001; http://www.kdhe.state.ks.us/tmdl/eutro.htm [Accessed 30 Sep 2002].

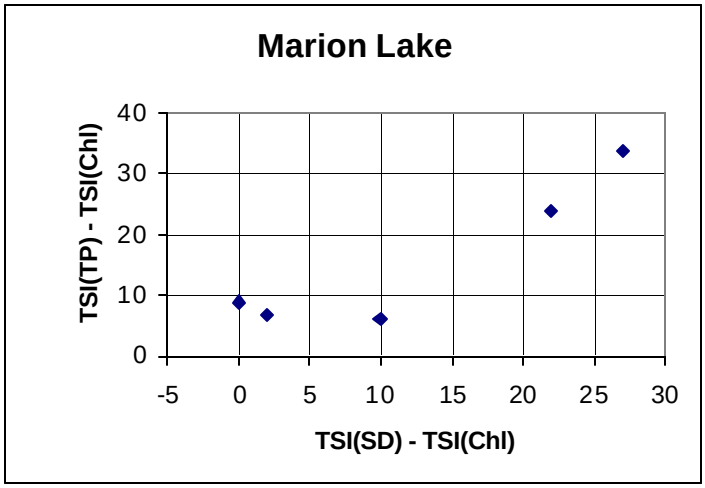
Mau, David P., and Pope, Larry M. 1999. Occurrence of Dissolved Solids, Nutrients, Pesticides, and Fecal Coliform Bacteria During Low Flow in the Marion Lake Watershed, Central Kansas, 1998. U.S. Geological Survey Water-Resources Investigations Report 99-4158.

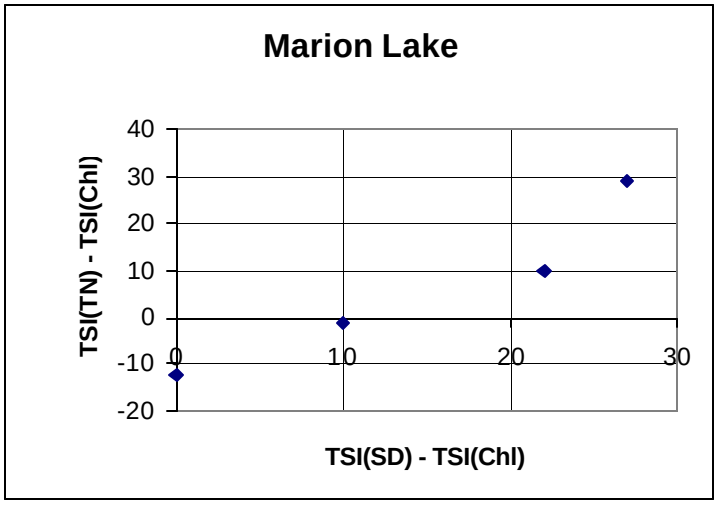
Appendix A - Boxplots





Appendix B - Trophic State Index Plots



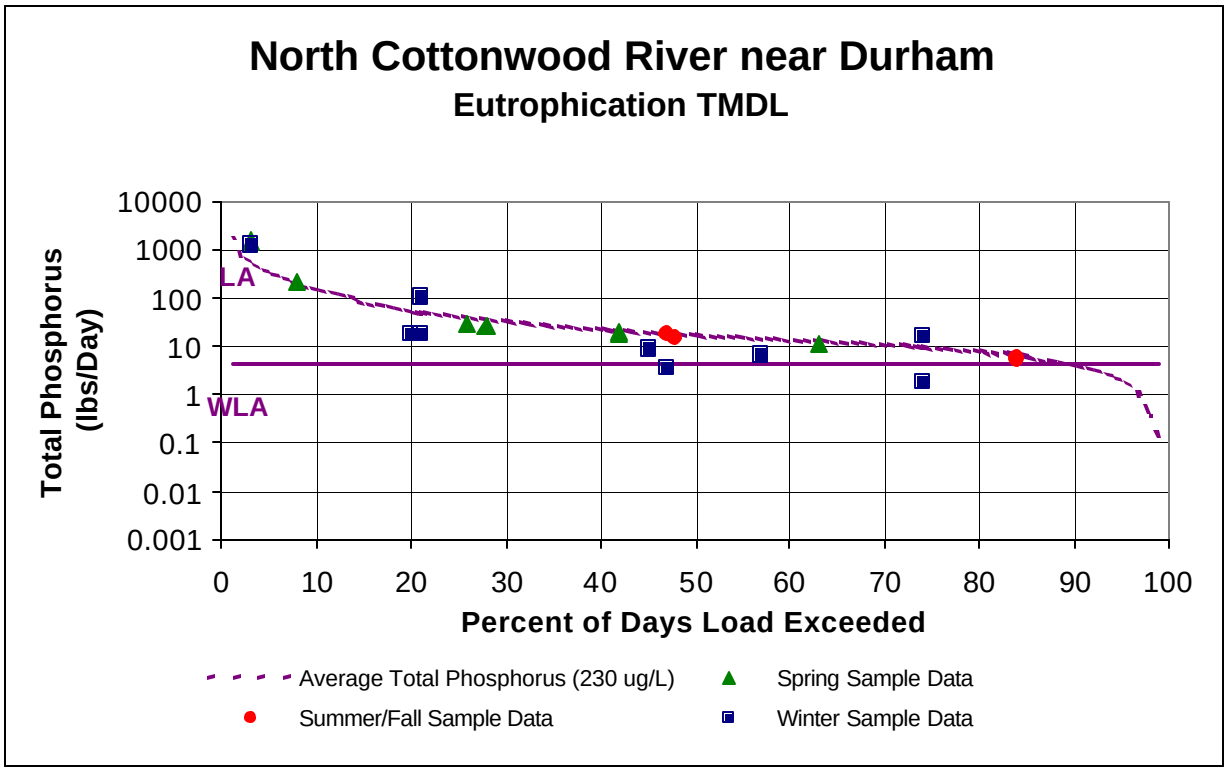


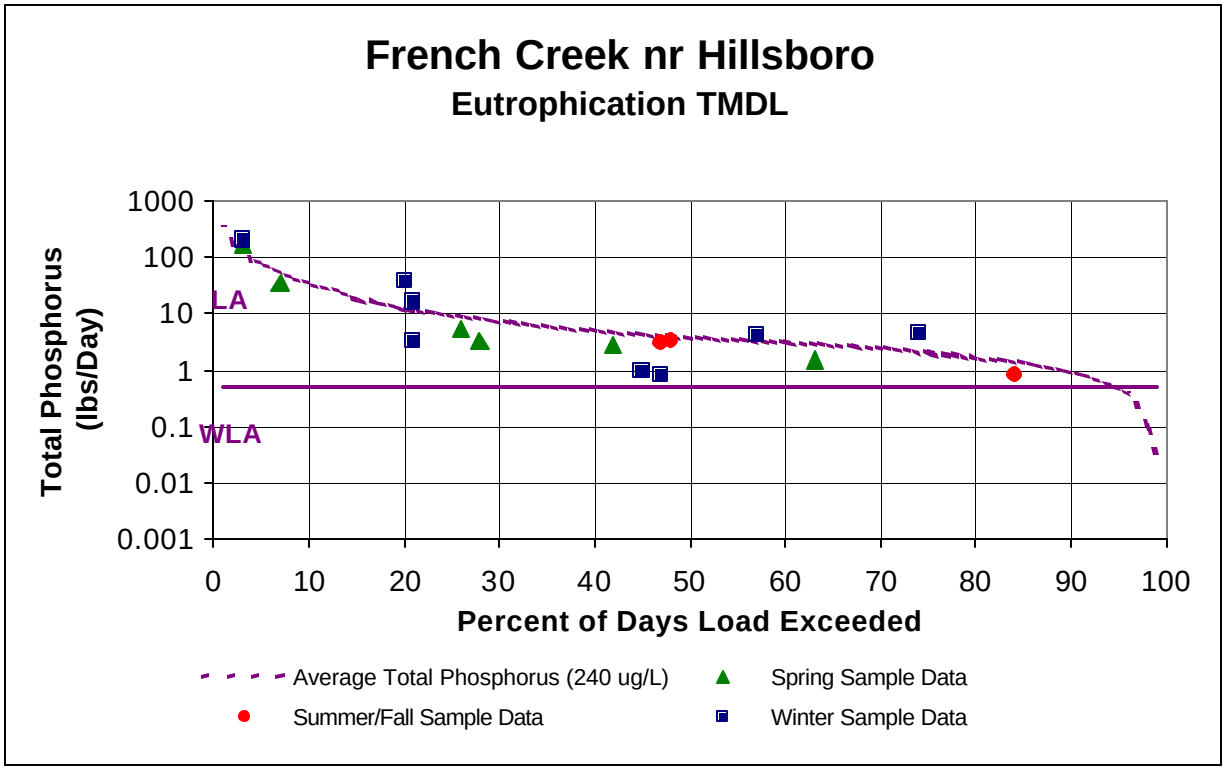
The Trophic State Index plots indicate that light is the primary limiting factor, due to clay turbidity. This is inferred by examining the relationship between the TSI(SD) - TSI(Chl) and TSI(TP)-TSI(Chl) or TSI(TN)-TSI(Chl). The deviation of chlorophyll from the sediment load indicates the degree of light penetration, while the difference between chlorophyll and phosphorus, or chlorophyll and nitrogen indicates the level of phosphorus or nitrogen limitation. Therefore, if the final plot is in the first quadrant, it shows that the transparency of the water is impaired due to the presence of small particles, and that phosphorus and nitrogen do not limit algae growth. The positive slope of the graph also indicates a correlation between phosphorus and transparency which is found when phosphorus is bound to non algal particles.

Appendix C - Load Duration Curves

The average Total Phosphorus concentrations are used in the graphs below to depict a baseline condition in the rivers. The graphs are analytical tools used to determine the influences of season and flow.

The Total Phosphorus reduction stated in this TMDL is for the water quality within Marion Lake. The allocation for pollutant reduction is detailed in section 4 of this TMDL. The curves do not represent Total Phosphorus TMDLs for station 636 (North Cottonwood River near Durham) nor station 676 (French Creek near Hillsboro).




French Creek nr Hillsboro
Eutrophication TMDL
Total Phosphorus (lbs/Day)
1000
100
10
1
0.1
0.01
0.001
LA
WLA
0
10
20
30
40
50
60
70
80
90
100
Percent of Days Load Exceeded
Average Total Phosphorus (240 ug/L)
Spring Sample Data
Summer/Fall Sample Data
Winter Sample Data

Appendix D - Input for CNET Model

Parameter	Value Input into CNET Model
Drainage Area (km^2)	529.5
Precipitation (m/yr)	0.79
Evaporation (m/yr)	1.44
Unit Runoff (m/yr)	0.11
Point Source Flow (hm^3/year)	0.25
Point Source Total P Concentration (ppb)	3,250.0
Surface Area (km^2)	21.8
Mean Depth (m)	3.4
Depth of Mixed Layer (m)	3.39
Depth of Hypolimnion (m)	0.97
Observed Phosphorus (ppb)	81.33
Observed Chlorophyl-a (ppb)	14.34
Observed Secchi Disc Depth (m)	0.69

Output from CNET Model

Parameter	Output from CNET Model
Load Capacity (LC)*	33,527 lb/yr
Waste Load Allocation (WLA)	1,782 lb/yr
Load Allocation (LA)	28,392 lb/yr
Margin of Safety (MOS)	3,353 lb/yr

***LC = WLA + LA + MOS**

7/30/04